Honors Chemistry - Atomic Structure & Energy of Electrons

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"Our eyes met and our souls caught on fire." — Nikki Rowe

Note: It is expected that you try the examples to the best of your understanding, and complete the problem sets by the test date and ask for help where needed.

1 A Brief History of Atomic Theory

A theory is defined as an explanation based on many observations.
A law is a fact of nature that is observed so often it is accepted as truth.

Atomic theory is the idea that matter is made up of atoms, the smallest pieces of matter.

Democritus was a Greek philosopher who first came up with the idea of an atom, however this was without experiment.

Laovisier proposed the Law of Conservation of Mass.

Proust proposed the Law of Definite Proportions.

Dalton proposed an atomic theory:
1. All matter is made up of tiny indivisible parts called atoms.
2. Atoms of the same element are identical, those of different elements are different.
3. Atoms of different elements combine in whole number ratios to create compounds.
4. Chemical reactions involve the rearrangement of atoms. No new atoms are created or destroyed.

Thomson was an English physicist who made a piece of equipment called the cathode ray tube. He discovered electrons this way.

Rutherford is known for his gold foil experiment. His model described the

atom as mostly empty, with a small concentrated nucleus.

Chadwick discovered the neutron.

Bohr proposed the electron cloud, in which electrons orbit the nucleus at a certain distance. Small orbits have a lower energy, and big orbits have higher energy.

2 Electron Configuration

This is today's model of the atom.

Electrons do occupy energy levels, but their exact path is not definite.
You cannot say with certainty that an electron will be at a specific point at any given time, however you know there is a high probability that the electron is located in an orbital around the nucleus.

Energy levels are the specific energies that electrons can have when occupying certain orbitals. Energy levels are broken up to sublevels, and they are broken down to orbitals which can hold two electrons each. There are four possible orbital shapes.

Orbital Shapes

You can determine which shape orbital an electron is in by looking at the element on the periodic table.

3 Electron Configuration

The location of electrons in orbit around the nucleus is what determines how the element will behave chemically.

There are three principles to understand electron configuration.

1. Aufbau Principle - electrons enter sublevels of the lowest energy first.
2. Pauli Exclusion Principle - all of the electrons in any single atom must be unique.
3. Hund's Rule - when electrons occupy orbitals of equal energy, one electron enters each orbital until all are half-filled with electrons spinning in the same direction before orbitals can be filled with opposite spin electrons.

Orbital Notation - shows where electrons are located. Orbitals are indicated with horizontal lines and electrons are shown as arrows. A maximum of two electrons can fit on any orbital.

Electron Configuration Notation - this gives the same information as orbital notation, but written more concisely.

Coefficients show the energy level, letters show the sublevels, and superscripts show the total number of electrons at that sublevel.

Example: Na: $1s^2 2s^2 2p^6 3s^1$

Noble Gas Core Method - Instead of writing the whole electron configuration, the symbol for the last element in the previous row is written in square brackets to represent all the electrons up until that noble gas.

Example: Na becomes [Ne]$3s^1$

Lewis Dot Notation - shows only the electrons available for bonding, known as valence electrons. There are the electrons in the highest energy level for that atom.

4 Structure of the Atom

The majors parts of the atom are:
1. Nucleus - dense, central part of the atom. Contains protons and neutrons.
2. Electron cloud - large area outside the nucleus. Contains electrons.

The atomic number is the number of protons in the nucleus of an atom. It determines the identity of an atom. It also tells you the number of electrons in the nucleus.

The Mass Number is the total number of protons and neutrons in the nucleus of an atom. Note that this is not the value listed on the periodic table.

The atomic mass is the number on the periodic table shown below the element symbol, and it is a weighted average of all the isotopes of that element.

Isotopes are atoms of the same element that have different mass numbers.

Hydrogen has 3 isotopes - protium, deuterium, and tritium.

When writing isotopes, there are two ways:
1. Superscript/Subscript method - The atomic number is written as a subscript the the mass is written as a superscript on the left of the element symbol.
2. Hyphen-Notation method - The symbol of the element written with a hyphen and then the mass number.

5 Relative Atomic Mass and Average Atomic Mass

The average atomic mass is the average of the masses of the naturally occurring isotopes, weighted for their abundance in nature. A general rule is that the most abundant isotope is the one whose mass number is closest to the average atomic mass, but this is not always the case.

Average atomic mass can be calculated by the formula: $\frac{(\text{mass})(\text{abundance})+(\text{mass})(\text{abundance})+\cdots}{100}$ = avg atomic mass.

6 Moles

In chemistry, the amount of substance is measured in moles. The mole is a standard number of particles. One mole contains 6.022×10^{23} particles.

Example: What is the mass in grams of 7.00 moles of iron?

Solution: 391 g Fe

7 Electromagnetic Spectrum

Wave-Particle Theories of Electrons

The Wave Model:
1. Light consists of electromagnetic waves that travel at the speed of light.
2. The electromagnetic spectrum includes the visible spectrum and other forms of radiation.
3. Electromagnetic radiation is also called electromagnetic waves. They have wave characteristics such as amplitude, frequency, and wavelength.
4. Since all EM waves travel at the same speed, as wavelength increases, the

frequency decreases. They are inversely proportional as given as $c = \lambda\nu$.
5. The visible spectrum is a continuous spectrum. A prism causes light to separate and produces the separate colors, but normally the colors blend together. Each color has a different frequency and wavelength.

The Particle Model:
Light can also act as a particle. You can calculate the energy of a photon using $E = h\nu$.